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APPARATUS AND PROCESS FOR AIR-COOLING AND TEMPERING A
GLASS SHEET

The present invention relates to an apparatus and a process for air-cooling and tempering a glass sheet, in particular, relates to an apparatus and a process for
5 air-cooling and tempering a glass sheet which cools and tempers a glass sheet by blowing cooling air to upper and lower surfaces of a curved glass sheet bent in a high temperature state.

10 An apparatus for producing a glass sheet for automobile windows by heating a glass sheet to a temperature close to the softening point in a furnace, bending it in a forming zone and quenching it in an air-cooling/tempering apparatus, has been known. The air-
15 cooling/tempering apparatus comprises a conveying apparatus for conveying a bent glass sheet, and air blowing members disposed above and under the conveying apparatus so as to sandwich the conveying apparatus. According to the conventional air-cooling/tempering
20 apparatus, when the whole of a glass sheet conveyed by

the conveying apparatus enters in an air-blowing area in which air is blown from upper and lower air blowing members, the conveying apparatus is stopped momentarily, and cooling air is blown from a plurality of air-nozzles of the upper and lower air-blowing members all at once for a predetermined duration to cool and temper the glass sheet. Thereafter, the conveying apparatus starts again to convey the air-cooled and tempered glass sheet to the next process (for example, refer to JP-A-2000-281369, p. 3 and Fig. 1).

The apparatus for producing an automobile window glass comprising a furnace, a forming zone and an air-cooling/tempering apparatus, can improve the productivity by air-cooling and tempering a glass sheet while it is continuously conveyed and by increasing the forming speed.

However, if the forming speed is increased in the forming zone, glass sheets are conveyed into the air-cooling/tempering apparatus with a short conveying interval. In the case of the conventional air-cooling/tempering apparatus, if the glass sheets are cooled and tempered as they are continuously conveyed under such condition, a next glass sheet located upstream a glass sheet being cooled and tempered will enter into the air-blowing area while the cooling air is blown. Therefore, there occurs a time lag between the start of blowing air to the front end of the glass sheet and the start of blowing air to the rear end, which causes uneven

cooling of the glass sheet.

Therefore, in the conventional air-cooling/tempering apparatus, there is a disadvantage that the conveying apparatus has to be stopped momentarily when a glass
5 sheet is cooled and tempered, namely, the conventional air-cooling/tempering apparatus can not cool and temper a glass sheet while it is continuously conveyed and accordingly, the productivity can not be increased.

The present invention has been made under these
10 circumstances, and it is an object of the present invention to provide an air-cooling/tempering apparatus and a process for air-cooling and tempering a glass sheet without adversely affecting the quality of the glass sheet while it is continuously conveyed.

15 The present invention provides, in order to achieve the above object, an apparatus for air-cooling and tempering a glass sheet, comprising:

a conveying means installed to be operable from a forming zone to a cooling area and to convey a glass
20 sheet in a high temperature state,

a plurality of upper blowing members provided in parallel along a conveying direction of glass sheet above the conveying means in the cooling area,

a plurality of lower blowing members provided in
25 parallel along a conveying direction of glass sheet under the conveying means in the cooling area,

a plurality of air-supply boxes provided in each of

the upper and lower blowing members for controlling
blow/stop operations of cooling air from each of the
blowing members, and

an air-supply source connected to these air-supply
5 boxes,

wherein each of the air-supply boxes comprises a
cylindrical damper having a perforated hole provided at
its side, a casing for rotatably accommodating the damper
and for forming an air channel only when the damper is at
10 a predetermined rotational position, and a slide bearing
provided in a space between the damper and the casing,
and wherein the cooling air supplied from the air-supply
source can be supplied to the upper and/or lower blowing
members through air channels by adjusting the rotational
15 position of the damper.

The present invention further provides the apparatus
for air-cooling and tempering a glass sheet, further
comprising a control means for controlling the rotational
position of a damper so that it

- 20 (a) stops cooling air to be blown from all of the upper
and lower blowing members in the cooling area in the
initial state,
(b) blows the cooling air from all of the upper and lower
blowing members when the substantially whole of a
25 conveyed glass sheet is entered in the cooling area, and
(c) sequentially stops the cooling air blown from the
upper and lower blowing members located behind the glass

sheet in response to the conveyance portion of the glass sheet after the last glass sheet in the cooling area is passed.

It is preferred that an upper and/or lower blowing member further comprises an air-nozzle swingable in the conveying direction of glass sheet.

Further, it is preferred that the conveying means is a conveyer comprising a plurality of rollers disposed in parallel along the conveying direction of glass sheet.

Further, it is preferred that the rollers move up and down according to the position of a glass sheet so that a curved glass sheet can be conveyed.

Further, it is preferred that a plurality of dampers are connected via an Oldham's coupling.

Further, it is preferred that the glass sheet is for a window glass of automobiles.

The present invention further provides a process for air-cooling and tempering a glass sheet comprising employing an apparatus for air-cooling and tempering a glass sheet, the apparatus comprising a conveying means installed to be operable from a forming zone to a cooling area and to convey a glass sheet in a high temperature state, a plurality of upper blowing members provided in parallel along a conveying direction of glass sheet above the conveying means in the cooling area, a plurality of lower blowing members provided in parallel along a conveying direction of glass sheet under the conveying

means in the cooling area, a plurality of air-supply boxes provided in each of the upper and lower blowing members so as to control blow/stop of cooling-air from each of the blowing members, and an air-supply source
5 connected to these air-supply boxes, the process being characterized by comprising:

- (a) a step of stopping cooling air from all of the upper and lower blowing members in the cooling area in the initial state,
- 10 (b) a step of blowing the cooling air from all of the upper and lower blowing members when the substantially whole of a conveyed glass sheet is entered in the cooling area, and
- (c) a step of sequentially stop the cooling air blown
15 from the upper and lower blowing members located behind the glass sheet in response to the conveyance position of the glass sheet after the last glass sheet in the cooling area is passed.

In the accompanying drawings:

20 Fig. 1 is a perspective view showing the structure of a bending apparatus for a glass sheet in which an air-cooling/tempering apparatus according to the present invention is incorporated.

Figs. 2(a) to 2(e) are diagrams illustrating a
25 bending operation of a glass sheet by a roller conveyor.

Fig. 3 is a diagram showing the structure of a rotation-driving means and vertical movement means of a

roller.

Fig. 4 is a cross-sectional view showing the structure of air nozzles of blowing members of the air-cooling/tempering apparatus.

5 Fig. 5 is a view showing the structure of a rotation mechanism and a vertical movement mechanism of a roller of the air-cooling/tempering apparatus.

Fig. 6 is a view showing the structure of a vertical movement mechanism of a blowing member of the air-cooling/tempering apparatus.

Fig. 7 is a perspective exploded view showing the structure of a damper of the air-cooling/tempering apparatus.

Fig. 8 is a side view of the damper shown in Fig. 7.

15 Figs. 9(a) and 9(b) are enlarged cross-sectional views showing a substantial part of the damper shown in Fig. 8.

Figs. 10(a) and 10(b) are diagrams illustrating the operation of the damper shown in Fig. 7.

20 Fig. 11 is a perspective view showing an embodiment wherein two dampers are connected via a coupling.

Figs. 12 to 16 are diagrams illustrating the operation of blow/stop operations of cool-air from air nozzles by open/close operations of a damper.

25 Now, the preferred embodiments of an air-cooling/tempering apparatus for a glass sheet according to the present invention will be described in detail with

reference to the attached drawings.

Fig. 1 is a perspective view showing the structure of a bending apparatus for a glass sheet in which the air-cooling/tempering apparatus according to this
5 embodiment is incorporated.

First, the flow of a glass sheet in the bending process will be described with reference to the figure. A glass sheet 18 before the bending process is positioned at the entrance of a furnace 12, introduced into the
10 furnace 12 by a roller conveyor for conveying, not shown, and heated up to a predetermined bending temperature (about from 600 to 700°C) in a process of being conveyed in the furnace 12.

The glass sheet 18 heated up to the bending
15 temperature, is transferred from the exit of the furnace 12 to a roller conveyor for bending to be conveyed in the forming zone 14. The glass 18 is formed into a shape having a predetermined curvature by an up/down moving operation of the roller conveyor for bending in the
20 process of being conveyed in the forming zone 14.

The curved glass sheet 18 is transferred from the exit of the forming zone 14 to a roller conveyor 22 for air-cooling and tempering (corresponding to the conveying means in Claims). The glass sheet 18 is conveyed by the
25 roller conveyor 22 for air-cooling and tempering into an air-cooling/tempering apparatus 16 to be cooled and tempered.

The glass sheet 18 cooled and tempered is transferred to a transferring roller conveyor 28, and conveyed to an inspection apparatus as a next process, not shown.

5 As described above, the glass sheet 18 is heated up to a bending temperature in the furnace 12, bent into a predetermined curved shape in the forming zone 14, and thereafter, cooled and tempered by the air-cooling/tempering apparatus 16 in the cooling area. Here,
10 a numeric symbol 11 indicates a controller for controlling the furnace 12, the forming zone 14 and the air-cooling/tempering apparatus 16.

Next, the construction of the forming zone 14 will be described. A roller conveyor 20 for bending shown in
15 Fig. 13 is constituted by a plurality of rollers 20A, 20B, ... each formed into a straight rod as shown in Fig. 2, and the rollers 20A, 20B, ... are disposed in parallel with a predetermined interval. The glass sheet 18 is conveyed along a conveying plane formed by the rollers
20 20A, 20B, ... by rotations of these rollers 20A, 20B, Further, each of the rollers 20A, 20B, ... constituting the roller conveyor 20 is independently rotated by a rotation driving means and independently moved in the vertical direction by a vertical driving means.

25 The structure of the rotation driving means and the vertical driving means installed in the forming zone 14, will be described. Here, since the rotation driving

means and the vertically driving means of the rollers 20A, 20B, ..., have each the same structure, only the structures of the rotation driving means and the vertical driving means of a roller 20A will be described, and the description regarding the structures of other rollers 20B, 20C, ..., is omitted.

Rotation driving means

As illustrated in Fig. 3, the roller 20A is rotatably supported at its both ends by bearings 32, 32 mounted on a vertically movable frame 30. Further, to the left end of the roller 20A in Fig. 3, a gear 34 is attached, and the gear 34 is engaged with a gear 36. The gear 36 is connected to a rotational shaft 40 of a servo motor 38 mounted on the vertically movable frame 30. By driving the servo motor 38, the roller 20A is rotated at a predetermined angular speed. This is all about the structure of the rotation driving means.

Vertical driving means

As illustrated in Fig. 3, the vertically movable frame 30 is supported by a fixed frame 42 so as to be movable up and down. Namely, guide rails 44, 44 are disposed vertically along both sides of the vertically movable frame 30, and the guide rails 44, 44 are engaged with guide blocks 46, 46 fixed to the fixed frame 42. Further, at both ends of a lower portion of the vertically movable frame 30, racks 48, 48 are provided so as to protrude downward therefrom. Pinions 50, 50 are

engaged with the racks 48, 48, and the pinions 50, 50 are fixed to a rotational shaft 52. The rotational shaft 52 is supported by the bearings 54, 54 at its both ends, and its left end portion in Fig. 3 is connected to a spindle 58 of a servo motor 56. When the servo motor 56 rotates the rotation shaft 52, the rotational movement is converted to a linear movement by the effect of the pinions 50 and the racks 48. Accordingly, the vertically movable frame 30 is moved up and down. And the roller 20A is moved up and down by the movement of the vertically movable frame 30. That is all about the structure of the elevating means. Here, numeric symbols 60, 62 in Fig. 3 indicate heaters provided in the forming zone 14.

15 The rotation driving means and the vertical driving means described above, are provided for all of other rollers 20B, 20C, ... The servo motors 38, 56 for these means are all controlled by a controller 11 in Fig. 1.

20 When a type of the glass sheet 18 is input from an external input means, the controller 11 prepares angular speed control data and up/down movement control data of the rollers 20A, 20B, ..., which correspond to the curvature of the glass sheet 18 of the type. Then, the controller controls the servo motors 38 based on the angular speed control data prepared, and controls the 25 servo motors 56 based on the up-down movement control data. Namely, the controller 11 carries out multi-axis

control of the rollers 20A, 20B, ..., so that the glass sheet 18 is bent to have a desired curvature in the conveying direction during the conveyance by the rollers 20A, 20B,

5 Bending operation of a glass sheet 18 by a roller conveyer 20 having the above construction, will be described with reference to Figs. 2(a) and 2(e).

 In the initial state, all the rollers 20A, 20B, ..., are at the top position as illustrated in Fig. 2(a). And
10 when the conveyance of the glass sheet 18 is started, the rollers 20D to 20F move down as illustrated in Fig. 2(b). Accordingly, the conveying plane defined by the rollers 20D to 20F deforms to have a gentle curved form having a large curvature radius. When the glass sheet 18 passes
15 on the rollers 20D to 20F, the glass sheet 18 bends by its own weight along a conveying plane defined by the rollers 20D to 20F, and is bent in the conveying direction.

 Thereafter, when the glass sheet 18 is further
20 conveyed as illustrated in Fig. 2(c), the rollers 20F to 20H move down more deeply than the previous rollers 20D to 20F. Accordingly, a conveying plane defined by the rollers 20F to 20H deforms to have a curved shape having a smaller curvature radius than the previous curved
25 conveying plane. Consequently, when the glass sheet 18 passes on the rollers 20F to 20H, the glass sheet 18 further bends by its own weight along the conveying plane

defined by the rollers 20F to 20H, and is bent in the conveying direction.

Thereafter, when the glass sheet 18 is further conveyed as illustrated in Fig. 2(d), the rollers 20H to 20J move down more deeply than the previous rollers 20F to 20H. Accordingly, a conveying plane defined by the rollers 20H to 20J deforms to have a curved shape having a smaller curvature radius than the previous curved plane. Consequently, when the glass sheet 18 passes on the rollers 20H to 20J, the glass sheet 18 further bends by its own weight along the conveying plane defined by the rollers 20H to 20J, and is bent in the conveying direction.

Thereafter, when the glass sheet 18 is conveyed forward as illustrated in Fig. 2(e), the rollers 20J to 20L move down more deeply than the previous rollers 20H to 20J. And a conveying plane defined by the rollers 20J to 20L deforms into a curved shape having the same curvature as the finally obtainable curvature of the glass sheet 18. When the glass sheet 18 passes on the rollers 20J to 20L, it is bent to have the finally obtainable curvature in the conveying direction. Thereafter, the rollers 20M and a succeeding roller move up and down so as to maintain the curved plane having this curvature.

As described above, the glass sheet 18 is bent in the conveying direction by sequentially decreasing the

curvature radius of the curved plane defined by the up/down movement of the rollers 20A, 20B, ... of the roller conveyer 20.

Next, the air-cooling/tempering apparatus 16 in Fig. 1 will be described. The air-cooling/tempering apparatus 16 cools and tempers a glass sheet 18 by blowing cooling air to the top and bottom surfaces of the glass sheet 18 being continuously conveyed by a roller conveyer 22 for air-cooling and tempering. Further, the roller conveyer 22 for air-cooling and tempering has a vertically movable structure like the roller conveyer 20 for bending.

The roller conveyer 22 shown in Fig. 1 is constituted by a plurality of rollers 22A, 22B, ... each formed in a straight rod as shown in Fig. 4, and the rollers 22A, 22B ... are disposed in parallel with a predetermined interval. Each of the rollers 22A, 22B, ... is independently rotated by a rotation driving means, and is independently moved up and down by a vertical driving means.

Next, the structure of the rotation driving means and the vertical driving means will be described. Here, since the rotation driving means and the vertical driving means of the rollers 22A, 22B, ..., have each the same structure, only the structures of the rotation driving means and the vertically movable means of a roller 22A will be described, and the description regarding the structures of other rollers 22B, 22C, ..., is omitted.

Rotation driving means

As illustrated in Fig. 5, the roller 22A is rotatably supported at its both ends by bearings 72A, 72A mounted on a pair of vertically movable frames 70A, 70A. Further, to the right end of the roller 22A in Fig. 5, an output shaft of a servo motor 78A is connected. By driving the servo motor 78A, the roller 22A is rotated at a predetermined angular speed. This is all about the structure of the rotation driving means.

10 Vertical driving means

A pair of vertically movable frames 70A, 70A are supported by a pair of fixed frames 82A, 82A respectively so as to be movable up and down. Namely, a guide rail 84A is disposed vertically along outside of each of the vertically movable frames 70A, and the guide rail 84A is supported by guide blocks 86A, 86A fixed to inside of the fixed frame 82A so as to be slidable. Further, at outside of the vertically movable frame 70A, racks 88A, 88A are provided, and pinions 90A, 90A are engaged with the racks 88A, 88A. The pinions 90A, 90A are fixed to a rotational shaft 92A, and the rotational shaft 92A is supported by the bearings 94A, 94A at its both ends. And to its right end portion in Fig. 5 is connected to a spindle of a servo motor 96A mounted at the top of one of the fixed frames 82A. When the servo motor 96A rotates the rotational shaft 92A, the rotational movement is converted to a linear movement by the effect of the

pinions 90A and the racks 88A. Accordingly, the vertically movable frame 70A is moved up and down, and the roller 22A is thereby moved up and down. That is all about the structure of the elevating means.

5 The rotation driving means and the vertical driving means described above, are provided for each of all other rollers 22B, 22C, ... The servo motors 78A, 78B, ..., 96A, 96B, ... for those means are all controlled by a controller 11 in Fig. 1.

10 When a type of the glass sheet 18 is input from an external input means, not shown, the controller 11 prepares angular speed control data and up/down movement control data of the rollers 22A, 22B, ..., which correspond to the curvature of the glass sheet 18 of the type. Then, the controller controls the servo motors 78A, 15 78B, ... based on the angular speed control data prepared, and controls the servo motors 96A, 96B, ... based on the up/down movement control data. Namely, the controller 11 carries out multi-axis control of the rollers 22A, 20 20B, ..., so that the glass sheet 18 bent in the forming zone 14 is conveyed as its shape is maintained.

 The main body of the air-cooling/tempering apparatus 16 is, as illustrated in Fig. 6, constituted by an upper air-supply box 100 disposed above the roller conveyor 22 and a lower air-supply box 102 disposed below the roller 25 conveyor 22 so that they sandwich the roller conveyor 22.

 To the upper air-supply box 100 and the lower air-

supply box 102, ducts 104 and 106 are respectively connected, and to these ducts 104 and 106, an air supply source 200 constituted by e.g. a blower is connected. Therefore, cooling air from the air supply source 200 is
5 supplied to the upper air-supply box 100 and the lower air-supply box 102 via ducts 104 and 106.

The upper air-supply box 100 is, as illustrated in Fig. 1, divided into air-supply boxes from 100A located most upstream in the conveying path of a glass sheet 18
10 (refer to Fig. 6) to 100J as tenth air-supply box, the lower air supply box 102 is divided into air-supply boxes 102A, ... in the same manner (a side of the air-supply box 102 is not shown), and the ducts 104 and 106 are connected to each of the divided boxes. Further, the
15 divided boxes have the respective air nozzles 25A to 25J and 27A to 27J (refer to Fig. 4). Further, the upper air-supply box 100 and the lower air-supply box 102 have, as shown in Fig. 12 to be described later, 20 air nozzles 25A to 25T and 27A to 27T respectively, and among them,
20 air nozzles 25A to 25J and 27A to 27J are disposed on the side of the 10 divided boxes, and the remaining air nozzles 25K to 25T and 27K to 27T are all connected to a 11th large-sized air-supply box, not shown. Here, in Fig. 1, the air-supply box 102, the 11th large-sized air-
25 supply box and the air nozzles 25K to 25T and 27K to 27T are omitted. Here, each of the air nozzles 25A to 25J in Fig. 4 employs a swingable head so as to blow air

perpendicularly to the conveying plane of a glass sheet. However, the present invention is not limited thereto. The nozzle may be of a type of fixed head.

The cooling air supplied to the upper air-supply box 100 in Fig. 6, is supplied to upper blowing members 24A, 24B, ... disposed above the rollers 22A, 22B, ... shown in Fig. 4 via three flexible ducts 108 in Fig. 6, and blown from air nozzles 25A, 25B, ... of the upper blowing members 24A, 24B, ... towards the roller conveyor 22. Meanwhile, cooling air supplied to the lower air-supply box 102 is supplied to lower blowing members 26A, 26B, ... provided under the rollers 22A, 22B, ... via three flexible ducts 110, and blown from air nozzles 27A, 27B, ... of lower blowing members 26A, 26B, ... towards the roller conveyor 22. Accordingly, the cooling air is blown to the top and bottom surfaces of a glass sheet 18 conveyed by the roller conveyor 22, whereby the glass sheet 18 is cooled.

Further, the upper blowing members 24A, 24B, ... and the lower blowing members 26A, 26B, ... are movable up and down. And the upper blowing members 24A, 24B, ... and the lower blowing members 26A, 26B, ... are moved up and down together with the rollers 22A, 22B, ... respectively. The rollers 22A, 22B, ... are moved up and down according to conveyance of a glass sheet 18. Here, among the rollers 22A, 22B, ..., rollers in a position where a glass sheet 18 is conveyed, move up and down so that a

conveying plane defined by the plurality of rollers in the position becomes a curved plane in the conveying direction of glass sheets, which corresponds to the curved shape of the bent glass sheet. Then, in accordance with the conveyance of the glass sheet, the rollers are sequentially move up and down so that the curved plane defined by the rollers proceed in the conveying direction of glass sheets.

Next, a mechanism for vertically moving the upper blowing members 24A, 24B, ... and the lower blowing members 26A, 26B, ... will be described. Here, since the mechanisms for all of the blowing members are the same, only the structure of the vertically movable mechanism of the upper blowing member 24A will be described. With respect to the structures of other upper blowing members 24B, 24C, ... and the lower blowing members 26A, 26B, ..., the same numeric symbols are applied, and description of these members will be omitted.

Vertically movable mechanism.

On both sides of the upper blowing member 24A shown in Fig. 6, frames 112, 112 are fixed, and these frames 112, 112 are attached to guide frames 114, 114 via sliders 116, 116, and supported so as to be vertically movable along the guide frames 114, 114. The guide frames 114 are provided at the lower portion of a supporting member 118 for supporting the upper air-supply box 100 so as to be extended vertically therefrom.

Further, racks 120, 120 are vertically attached to the frames 112, 112, and pinions 122, 122 are engaged with these racks 120, 120. The pinions 122, 122 are attached to a shaft 124, and the shaft 124 is supported
5 by the supporting member 118 via bearings 126, 126, and the right end portion of the shaft 124 in Fig. 6 is connected to a rotational shaft of a servo motor 128. Therefore, when the shaft 124 is rotated by a servo motor 128, the rotation is transformed into a linear movement
10 by the effect of the pinions 122 and the racks 120. Accordingly, the upper blowing member 24A is moved in the vertical direction. That is all about the structure of the vertically movable mechanism.

The vertically movable mechanism is provided for
15 each of other upper blowing members 24B, 24C, ... and the lower blowing members 26A, 26B, And all of the servo motors 128, 128, ... of these vertically movable mechanisms are controlled by the controller 11 in Fig. 1.

When a type of glass sheet 18 is input from an
20 external input means, not shown, the controller 11 prepares up/down movement control data of the upper blowing members 24A, 24B, 24C, ... and the lower blowing members 26A, 26B, ..., which correspond the curvature of the glass sheet 18 of the type. Then, the controller
25 controls the servo motors 128, 128 ... based on the up/down movement control data prepared. Namely, the controller 11 moves up and down the upper blowing members

24A, 24B, ... and the lower blowing members 26A, 26B, ...
opposing to the upper blowing members 24A, 24B, ... in
accordance with the vertical position of the rollers 22A,
22B, ... maintaining constantly the distance between the
5 upper blowing members 24A, 24B, ... and the lower blowing
members 26A, 26B, ... Accordingly, the distance between
the top surface of the glass sheet 18 and the upper
blowing members 24A, 24B, ... and the distance between
the bottom surface of the glass sheet 18 and the lower
10 blowing members 26A, 26B, ... are controlled to be
constant.

Here, the divided air-supply boxes 100A to 100J
shown in the upper side in Fig. 1, are provided with
dampers 130 shown in Fig. 7. Ten divided air-supply
15 boxes in the lower side, not shown in Fig. 1, are also
provided with the same dampers 130.

Each of the divided air-supply boxes 100A to 100J
shown in Fig. 7, comprises an upper casing 134 made of
e.g. SUS formed to have three openings 132 to be
20 connected to a blower side, and a lower casing 136 made
of e.g. SUS formed to have three openings 133 to be
connected to three flexible ducts 108 shown in Fig. 6,
and is constituted by combining them so that three
openings 132 of the upper casing 134 and three openings
25 133 of the lower casing 136 are in line with each other
in the vertical direction. Further, on each of mating
faces of the upper casing 134 and the lower casing 136, a

channel 138 having an arcuate cross section as shown in Fig. 8 is formed, and a damper 130 is disposed in a space having a circular cross section formed by these channels 138, 138.

5 The damper 130 made of a metal of e.g. SUS is formed into a cylindrical shape, and three perforated holes 142 are formed in the longitudinal direction. The damper 130 is disposed in the position in which its three perforated holes 142 are in line with three openings 132 of the
10 upper casing 134. Further, the damper 130 is rotatably supported in the lower casing 136 via a pair of slide bearings 144, 144 shown in Fig. 8 each made of metal and formed into a long plate shape. Air channels are provided in the air-supply box when the perforated holes
15 142 and the openings 132 in the upper and lower side are in line with one another, whereby cooling air is supplied from the air supply source 200 to the blowing members.

 Further, each of the slide bearings 144 is inserted into a channel 146 formed in the lower casing 136 as
20 shown in Figs. 9(a) and 9(b). Further, for the slide bearing 144, flush bolts 148 and springs 149 are alternately provided along the longitudinal direction. The slide bearing 144 is fixed to the lower casing 136 by tightening the flush bolts 148, 148, ... to the lower
25 casing 136, and is pushed against the damper 130 by a force of the springs 149. A cooler 145 determines the height of the flush bolt 148, and allows the slide

bearing 144 to have a predetermined stroke. The damper 130 is stably supported in the central position of the spacing having a circular cross section by this tension.

To a shaft 131 formed at the end of the damper 130
5 shown in Fig. 7, an output shaft 152 of a motor 150 is connected via a reduction mechanism, not shown. Thus, when a rotational force of the motor 150 is transmitted to the damper 130, the damper 130 is rotated in the space 140.

10 Further, the rotation of the damper 130 is controlled by the controller 11 shown in Fig. 1 so as to turn every 90° with respect to the reference position where the perforated holes 142 of the damper 130 and the openings 132 of the upper casing 134 and the openings 133
15 of the lower casing are in line. Therefore, the damper 130 is driven intermittently between an open position as shown in Fig. 10(a) in which the perforated holes 142 of the damper 130 and the openings 132 and 133 are in line, and a close position as shown in Fig. 10(b) in which the
20 perforated holes 142 are shifted by 90° from the openings 132 and 133. By this open/close operation, supply/stop of cool-air to the upper blowing members 24A to 24J and the lower blowing members 26A to 26J as shown in Fig. 1 are performed.

25 Fig. 11 shows another embodiment of a divided air-supply box 101 for blowing cooling air upwardly from below the glass sheet 18 towards the glass sheet 18. The

divided air supply box 101 is constituted as a single unit by connecting divided air-supply boxes 100 in Fig. 7 each having three openings 132 and three openings 133, together in the longitudinal direction and by connecting
5 dampers, not shown, provided in each of them via an Oldham's coupling. By employing the divided air-supply box 101, the number of openings is increased from three to six, whereby it is possible to make the upward air flow larger than the downward air flow.

10 Next, the control method for the dampers 130, 130, ... is described with reference to diagrams of blow/stop operations of air nozzles 25A to 25J and 27A to 27J shown in Figs. 12 to 16. Here, nozzles for blowing cooling air are each indicated by a white box, and
15 nozzles in a stopped state are each indicated by a black square. Further, in order to illustrate blow/stop operations of the nozzles in a easy way to understand, a conveying path constituted by a roller conveyer 20 for bending and a roller conveyer 22 for air-cooling and
20 tempering are illustrated in a straight shape. Further, since the dampers 130 are not provided in air nozzles 25K to 25T and 27K to 27T, cooling air is continuously blown from the air nozzles 25K to 25T and 27K to 27T. Here, in the initial state, air blown from all of the air nozzles
25 in the cooling area is stopped.

Fig. 12 shows a state that two advanced glass sheets 18A and 18B are being air-cooled and tempered as they are

continuously conveyed by a roller conveyer for air-cooling and tempering, and a third glass sheet 18C has been conveyed to the entrance of an air-cooling/tempering apparatus 16. Further in this production apparatus 10, since the conveying speed is high in a forming zone 14, the glass sheets 18 are continuously conveyed into the air-cooling/tempering apparatus 16 with reduced intervals between the glass sheets.

The first advanced glass sheet 18A is continuously conveyed as it is cooled and tempered by cooling air blown continuously from the air nozzles 25M to 25T and 27M to 27T. Meanwhile, the second advanced glass sheet 18B is passed a cooling-air blowing area from the air nozzles 25A to 25J and 27A to 27J which are subjected to blow/stop operations by dampers 130, and therefore, the controller 11 (refer to Fig. 1) controls to open the dampers 130, 130, ... for the air nozzles 25C to 25J and 27C to 27J capable of blowing cooling air to the cooling-air blowing area where the glass sheet 18B is located. Accordingly, the glass sheet 18B is continuously conveyed as the whole of it is cooled and tempered by cooling air blown from the air nozzles 25C to 25J and 27C to 27J. Here, the controller 11 is controlling to close the dampers 130, 130, ... of the air nozzles 25A, 25B, 27A and 27B in the cooling-air blowing area where the glass sheet 18B has already passed. This operation is to prepare for the third glass sheet 18C entering into the

air-cooling/tempering apparatus 16.

Fig. 13 illustrates a state that the first glass sheet 18 is being transferred from the air-cooling/tempering apparatus 16, and the second glass sheet 18B is still being air-cooled and tempered as it is continuously conveyed. As illustrated in the figure, after the glass sheet 18B as the last glass sheet in the cooling area (if there is only one glass sheet in the cooling area, it is that glass sheet) is passed, the blowing operation of cooling air from the upper and lower blowing members behind the glass sheet 18B is sequentially stopped, so as to follow the movement of the glass sheet 18B being conveyed. Further, the figure shows a state that the leading edge in the conveying direction of a third glass sheet 18C is brought into the air-cooling/tempering apparatus 16 by the roller conveyor 22 for air-cooling and tempering.

Since the second glass sheet 18B has already passed the cooling-air blowing area of the air nozzles 25A to 25J and 27A to 27J which are subjected to blow/stop operations by a damper 130, the controller 11 (refer to Fig. 1) controls to open the dampers 130, 130, ... for the air nozzles 25F to 25J and 27F to 27J capable of blowing cooling-air to a cooling-air blowing area in which the glass sheet 18B is located. Accordingly, the whole of the glass sheet 18B is cooled and tempered by cooling air blown from the air nozzles 25F to 25J and 27F

to 27J and the air nozzles 25K to 25M and 27K to 27M as the glass sheet 18B is continuously conveyed. Here, the controller 11 controls to close the dampers 130, 130, ... for the air nozzles 25A to 25E and 27A to 27E in a cooling-air blowing area in which the glass sheet 18B has already passed since the whole of the third glass sheet 18C has not entered into the cool-air tempering apparatus 16 yet.

Fig. 14 shows a state just before the first glass sheet 18A is transferred from the air-cooling/tempering apparatus 16, and a state that the second glass sheet 18B is continuously cooled and tempered as it is continuously conveyed. Further, the figure shows a state that about a half of the third glass sheet 18C has entered in the air-cooling/tempering apparatus 16.

Since the second glass sheet 18B is passing the air-cooling blowing area of the air nozzles 25A to 25J and 27A to 27J which are subjected to blow/stop operations by a damper 130, the controller 11 (refer to Fig. 1) controls to open the dampers 130, 130, ... for the air nozzles 25H to 25J and 27H to 27J capable of blowing cooling-air to the cooling-air blowing area in which the glass sheet 18B is located. Accordingly, substantially the whole of the glass sheet 18B is cooled and tempered by cooling air blown from the air nozzles 25H to 25J, 27H to 27J and air nozzles 25K to 25P and 27K to 27P, as the glass sheet 18B is continuously conveyed. Air blow does

not have to be started after the glass sheet 18C is completely entered in the cooling area, but the blowing may be started in a state that the glass sheet 18C still protrudes from the cooling area by about the width of the
5 air nozzle 25A or 27A.

Here, the controller 11 controls to close the dampers 130, 130, ... for air nozzles 25A to 25G and 27A to 27G in the cooling-air blowing area in which the glass sheet 18B has already passed. This operation is because
10 the whole of the third glass sheet 18C has not entered in the air-cooling/tempering apparatus 16 yet.

Fig. 15 shows a state that the first glass sheet 18A has completely transferred from the air-cooling/tempering apparatus 16, and a state that the second glass sheet 18B
15 is being continuously cooled and tempered as it is continuously conveyed. Further, a state that the substantially whole of the third glass sheet 18C has entered in the air-cooling/tempering apparatus 16. At this moment, the controller 11 (refer to Fig. 1) controls
20 to open the dampers 130, 130, ... for the air nozzles 25A to 25J and 27A to 27J. Accordingly, the substantially whole of the third glass sheet 18C is cooled and tempered by cooling-air blown from air nozzles 25A to 25H and 27A to 27H, as it is continuously conveyed.

25 Fig. 16 shows a state that the second glass sheet 18B is being transferred from the air-cooling/tempering apparatus 16, and a state that the third glass sheet 18C

is continuously cooled and tempered as it is continuously conveyed. Further, the figure shows a state that a fourth glass sheet 18D has conveyed to the entrance of the air-cooling/tempering apparatus 16 by a roller
5 conveyer 20 for bending.

Since the third glass sheet 18C has already passed the cooling-air blowing area of the air nozzles 25A to 25J and 27A to 27J which are subjected to blow/stop operations by a damper 130, the controller 11 (refer to
10 Fig. 1) controls to open the dampers 130, 130, ... for the air nozzles 25C to 25J and 27C to 27J capable of blowing cooling air to the cooling air blowing area in which the glass sheet 18C is located. Accordingly, the whole of the glass sheet 18C is cooled and tempered by
15 cooling-air blown from the air nozzles 25C to 25J and 27C to 27J, as the glass sheet 18C is continuously conveyed. Here, the controller 11 controls to close the dampers 130, 130, ... for the air nozzles 25A, 25B, 27A and 27B in the cooling-air blowing area in which the glass sheet 18C has
20 already passed. This operation is done since the whole of the fourth glass sheet 18D has not entered the air-cooling/tempering apparatus 16 yet.

As described above, according to the air-cooling/tempering apparatus 16 of this embodiment, as
25 illustrated in Fig. 15, a controller 11 controls a plurality of dampers 130 for a plurality of air nozzles 25A to 25J and 27A to 27J capable of blowing cooling air

to a cooling-air blowing area, so that cooling-air is blown all at once to the glass sheet 18 from the plurality of air nozzles 25A to 25J and 27A to 27J.

And as illustrated in Figs. 12 to 14, the controller
5 11 controls the plurality of dampers 130 so as to sequentially stop the blow of cooling air from the plurality of air nozzles 25A to 25J and 27A to 27J at a position corresponding to the position in which the glass sheet 18 has already passed, so as to follow the movement
10 of the glass sheet 18 conveyed by the roller conveyor 22 for air-cooling and tempering. Accordingly, the glass sheet 18 can be air-cooled and tempered as the glass sheet 18 is continuously conveyed without adversely affecting the quality of the glass sheet 18.

15 Here, description has been made with respect to an air-cooling/tempering apparatus for a bent glass sheet in the embodiment. However, the present invention is not limited thereto but can be applied to an air-cooling/tempering apparatus for flat glass sheets.

20 As described above, an air-cooling/tempering apparatus for a glass sheet according to the present invention, employs rotation type dampers having an excellent durability, whereby blow/stop operations of cooling air can be controlled frequently blow/stop
25 operations of cooling air can be controlled precisely according to the position of a glass sheet being conveyed, and a glass sheet can be cooled and tempered without

stopping the conveyance. In the present invention in particular, since cooling air can be blown to the whole of the glass sheet entered in the cooling area, uneven cooling does not occur and a high quality glass sheet can
5 thereby be produced.

Here, the present invention can be suitably applied to the production of a glass sheet for automobile use. It can also be applied for e.g. a window glass employed for ships, airplanes, trains or architectural structures.

10 The entire disclosure of Japanese Patent Application No. 2002-275149 filed on September 20, 2002 including specification, claims, drawings and summary is incorporated herein by reference in its entirety.